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The Charnley Hip Replacement – 43 Years of Clinical Success

Totální náhrada kyčelního kloubu podle Charnleyho – 43 let klinického úspěchu

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SUMMARY

The Carnley low-frictional torque arthroplasty of the hip with 22.225 mm diameter head and thick ultra high molecular weigh polyethylene cup, both components grouted with cold curing acrylic cement, has reached 43 years of clinical success. Follow-up past 30 years is now available. Over 96% of patients are satiscied with the result. Post operative activity level is a reflection of patient selection. The neuropathic nature of the new joint does not reflect the mechanical state of the arthroplasty: regular follow-up with good quality radiographs is essential. Revisions may have to be undertaken for asymptomatic radiographic changes: a principle that must be understood and accepted before the primary procedure.

The long-term problems are wear and cup loosening and strain shielding of the proximal femur. Long-term success will be further extended by understanding and practical application of the principles at the primary procedure and use of low wear materials for the articulation. The operation of total hip arthroplasty marks the beginning and not the end of treatment.

INTRODUCTION

November 1962 marks the beginning of the era of a new speciality within orthopaedics – total hip replacement surgery.

This was the date when Charnley working in Wrightington Hospital introduced his method, which has become not only the basis for other designs, but also the source of information for joint replacement in general. That crucial point was the introduction of ultra high molecular weight polyethylene as the material for the cup.

It must be appreciated that the scientific basis, the concept, the design, instrumentation and the surgical technique were already well established.

Successful clinical results uncovered the demand for the operation, extended the indications and increased patients' expectations. Commercial competition brought with it proliferation of designs, materials and techniques of component fixation. The Charnley hip replacement, the low frictional torque arthroplasty (LFA) did not stand still. Improvements, at every level, were brought in purposely as a result of the study of long-term outcomes, findings at re-operations and examination of explanted components.

The name Charnley remains closely linked with the prosthesis, what is often forgotten is the concept and the technique. It may, therefore, not be out of place if the reader is reminded of the basics of this operation.

THE THEORY

The low frictional arthroplasty

In the evolution of the operation Charnley initially attempted to emulate nature: the low friction characteristics of joint cartilage. Polytetrafluorethylene (PTFE – Teflon) was used as a synthetic cartilage (1) initially as interposition shells, then with femoral head replacement (Austin-Moore, Thompson). Clinical success was short lived: the problem was wear of PTFE.

Low-frictional torque

It was suggested to Charnley (2) that the problem may be overcome by directing the attention to the design – reducing the diameter of the head of the femoral component from the initial 41.5 mm to 28, 25 and eventually 22.225 mm (Charnley worked with the then Imperial System 7/8 in = 22.225 mm). (The principle defines the tangential force acting through different length levers. With a short radius of the head of the small femoral component (11.1125 mm) and a long radius of the outer limit of the cup eg: 20 or 21.5 mm – the movement, under load, is more likely to take place at the level of articulation than at the bone – implant interface and hence less likely to lead to component loosening). It is that change from the property of the materials to the principle of the design that marks the beginning of the Charnley concept.

Surgical technique

With the patient supine lateral exposure with trochanteric osteotomy is routine. The details have been modified to improve the trochanteric union rate (12) but the basic principle of improving the mechanical lever ratios of the artificial hip (4) have remained unchanged. Instrumentation and the surgical technique were established during the Teflon era.

The exposure of the acetabulum is to the level of the "tear drop" the cup is medialised but only to achieve full coverage within the acetabulum while preserving the subchondral bone. The cup is fixed in neutral orientation and 45° open laterally.

Neutral orientation of the stem within the medullary canal is the aim accepting the anatomy of the proximal femur, the calcar femorale (15) and the complete cement mantle. The access is through the piriformis fossa and not the sectioned neck of the femur. The medullary canal is closed off distally preferably with a cancellous bone block (13).

Trochanteric position was used to improve the lateral lever by its re-attachment, not only laterally, but also distally. This is now achieved by selecting a suitable offset stem.

Excision of the capsule has never been a part of the procedure; its relative lack of elasticity, unlike the muscle, gives a good feel for stability at trial reduction and a very low incidence of post-operative dislocation (8).

Fixation of components

"The crux of this operation lies in the use of cement. By means of cement the load of the body weight is distributed over a large area of bone" (3). Some aspects of surgical technique of component fixation with acrylic cement is outside this brief review. The principle and the objectives are well summarised in Charnley's statement: "load distribution over a large area of bone" (3) hence exposure, preparation of bone, cement injection: a skill that is acquired with practice. Histology of the bone-cement interface has been studied extensively, first by Charnley himself (6) then by Malcolm (9) with the support of the John Charnley Trust.

Although acrylic cement is used for both the cup and the stem fixation, the function of the two implants within the human body is slightly different. On the acetabular side the cup and the cement form a single unit – failures will be at the bone-cement interface. On the femoral side the aim must be the common engineering principle that of tapers – male – the stem – and the female – cement and femur -engaging under load to ensure not only the stability of the stem but also proximal load transfer to the femur. The demand is a complete mantle of well injected cement and no distal stem support (16).

Clinical results

In order to understand the reasons for the clinical success, the need for regular follow-up with good quality radiographs and early intervention in cases of impending failures, it is essential to understand and accept the very simple fact: the arthroplasty is a foreign body bursa housing a neuropathic spacer. It is subject to fatigue, wear and changes in volume and pressure. Furthermore, because of the altered pattern of load transfer, the medullary canal becomes load-bearing, it imposes changes on that part of the skeleton on the principle of Wolfe's Law (10).

Pain relief

Freedom from pain can be taken for granted subject to correct patient selection and sound fixation of components. It is this aspect of clinical practice that was the driving force that made Charnley persevere with his efforts. The recording of this parameter has various methods which are valid. Two aspects are worth remembering: first pain at rest, especially at night soon demoralises an individual and becomes almost an absolute indication for surgery, and second memory for pain is very poor, fortunately, and retrospective studies have little to commend.

Function

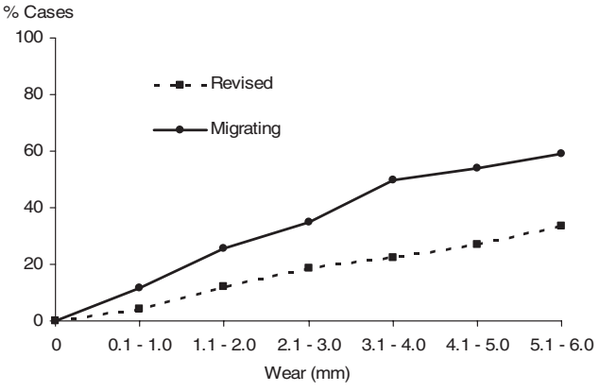
Study and recording of patients' function is a very complex issue. There is no single method to take all

Table 1. Indications for revision

Indication	Number of hips	Percentage
Infection	22	1.53
Dislocation	6	0.42
Loose cup / cup wear	167	11.7
Loose stem	70	4.9
Fracture stem	22	1.7
Unexplained pain	2	0.14
Other explorations e.g removal of trochanteric wires	20	1.4

Some patients had more than a single indication.

Fig 1. The incidence is exponentially related to the depth of cup penetration



Cup Penetration (mm)	0	0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0
Number of cases	47	630	291	217	116	48	27
Number Migrating	0	73	75	76	58	26	16
% Migration	0	11.6	25.8	35.0	50.0	54.2	59.3
Number revised	0	27	35	40	26	13	9
% Revised	0	4.3	12.0	18.4	22.4	27.1	33.3

Fig. 2. a – Pre-op radiograph, b – radiograph at one year, c – radiograph at 30 year follow-up

aspects into account and even a most simple parameter will have a vast range, (Olympic games is a perfect example: single event but only one winner.)

A method of d'Aubigne and Postel (7) as modified by Charnley (5) is as good as any. Anecdotal, single case successes attract attention and increase expectations in prospective patients. Single case spectacular results are not a feature of a particular type of arthroplasty: they are a reflection of patient selection. Patients with multiple disabilities never feature as anecdotal single case successes.

Range of movement

Range of movement of a total hip has been a subject of frequent comments often in context of post-operative dislocation. A "socially acceptable" range is probably adequate for most activities. Excessive range plus the neuropathic nature of the joint invites dislocation.

Long term studies

With increasing demand for THA the emphasis is focused on long-term results. Such studies will invariably identify young patients yet without the benefit of the latest advances in the design, materials or surgical technique.

The Charnley hip replacement has now reached 43 years of clinical experience. Follow-up in some patients has passed 35 years (14). Out of a group of 1092 patients, 1434 primary Charnley LFAs, under the age of 51 at the time of surgery, 759 patients (951 hips) who were attending did not have a revision: with a mean follow-up of 17 years and 5 months, 96.2% were satisfied with the outcome.

The details of revisions are shown in Table I.

The main long term problem was wear and loosening of the UHMWPE cup. The incidence is exponentially related to the depth of cup penetration. Fig. 1.

With revision, for any indication as the end point the survivorship was 93.7% (92.3–95.0) at 10 years, 84.7%

(82.4–87.1) at 15 years, 74.3% (70.5–78.0) at 20 years and 55.3% (45.5–65.0) at 27 years, when 55 hips remained "at risk".

Prospects for the future – ongoing developments

There is little doubt that the operation of hip replacement will remain a permanent method of treatment for the symptomatic destroyed hip. It could be argued that the success of the operation has delayed if not eliminated altogether the desire for the investigation and treatment of underlying hip pathology in some conditions.

Hip replacement in general and revision surgery in particular has become a sub-speciality within orthopaedics. The demand is not merely for numbers but for the quality, research and development. Past experience and prospective studies indicate that the most likely long-term benefits will come from:

1) A well executed primary operation by a surgeon skilled in the technique.
2) Introduction of wear resistant materials for the articulation. Experience to date suggests that damage resistant material for the head of the femoral component (17,18) is likely to be of greater benefit than cross-linked polyethylene.
3) Improving the stem design by reducing the diameter of the neck from 12.5 to 10mm has been shown to reduce the likelihood of impingement (11) and thus reduction in the incidence of cup loosening and revision by 56% (19).
4) Avoiding distal stem support will reduce the incidence of proximal strain shielding of the femur (16).

Long term success can be achieved with early component designs, materials and surgical techniques if wear of the UHMWPE can be reduced to a minimum (Fig 2a,b,c). (Note the design of trochanteric reattachment.)

ZÁVĚR

Totální náhrada kyčelního kloubu podle Charnleyho používající komponenty s nízkým třením, s hlavicí o průměru 22 mm a jamkou ze silného ultravysokomolekulárního polyetylenu, přičemž obě komponenty jsou ukotveny akrylátovým cementem tuhnoucím za studena, dosáhla 43 let klinického úspěchu. V současnosti jsou dostupné výsledky sledování za posledních 30 let. Více než 96 % pacientů je s výsledkem spokojeno. Neuropatická povaha nového kloubu neodráží mechanický stav náhrady: podstatná je pravidelná kontrola na základě kvalitních rtg-snímků. Při radiografickém zjištění asymptomatických změn lze uvažovat o nutnosti revize. To je zásada, kterou nutno pochopit a akceptovat ještě před primární operací.

Dlouhodobými problémy jsou otěr, uvolnění jamky a stress-shielding proximálního femuru. Dlouhodobá úspěšnost se zvýší pochopením a praktickým uplatňováním daných zásad pro primooperaci a používáním nízkootěrových materiálů. Operační výkon při totální náhradě kyčelního kloubu znamená začátek a ne konec léčení.

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